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US ARMY
LABORATORY COMMAND

CONTRACT REPORT NUMBER 3-91

PREPARED FOR THE

HUMAN ENGINEERING LABORATORY

BY

ASI SYSTEMS INTERNATIONAL
Aberdeen Group
211 West Bel Air Avenue
Aberdeen, MD 21001

HOOKLIFT INTERFACE KIT (HIK) PHASE II DESIGN FIELD TEST RESULTS

FINAL REPORT

Contract Number DAAD05-89-C-0071

March 1990

US ARMY HUMAN ENGINEERING LABORATORY
HEL
ABERDEEN PROVING GROUND, MARYLAND

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

ABERDEEN PROVING GROUND, MARYLAND 21005-5001

COPY 2 OF 8

ASI 90-01

HOOKLIFT INTERFACE KIT (HIK) PHASE II DESIGN FIELD TEST RESULTS

Contract Number: DAAD05-89-C-0071

FINAL DRAFT REPORT

March 1990

By

D. J. Shearin, Sr

Prepared For:

Combat Service Support Division
U.S. Army Human Engineering Laboratory
Aberdeen Proving Ground, Maryland 21005-5001

ASI SYSTEMS INTERNATIONAL
Aberdeen Group, P.O. Box 158
211 W. Bel Air Avenue, Aberdeen, MD 21001

20 MARCH 1990

SUBJECT: Transmittal of Draft copy of ASI Report 90-01, Hooklift Interface Kit (HIK) Phase II Design Field Test Results.

TO: Director
U.S. Army Laboratory Command
Human Engineering Laboratory
ATTN: SLCHE-CS (Mr John J. Salser)
Aberdeen Proving Ground, MD 21005-5001

Dear Mr Salser:

Reference is made to Contract DAADO5-89-C-0071, as amended. The above referenced document calls for the preparation of a final draft report containing the results of field tests of the Phase II Design Intermodal Ammunition Container (AMCON) and the Hooklift Interface Kit (HIK), including an analysis of the test data and recommendations for engineering design changes as appropriate. During a recent IPR, the COTR requested the results of the field testing of the AMCON and HIK be provided as separate reports.

A final draft copy of the HIK field test results, prepared in accordance with above guidance, is forwarded herewith in triplicate. The final draft report containing the results of the AMCON field testing will be provided within thirty days from date of this letter.

Sincerely,

Allan R. Burke, Director
Aberdeen Operations

ARB/djs

ASI Systems International
944 W. Bel Air Avenue P.O. Box 458 Aberdeen MD 21001 (301) 272-0800

ASI 90-01

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Prepared For:

Combat Service Support Division
U.S. Army Human Engineering Laboratory
Aberdeen Proving Ground, Maryland 21005-5001

PREFACE

The work recorded in this report was authorized under Contract DAAD05-89-C-0071, dated 1 October 1989. Experimental prototype testing was performed on a Phase II Design Hooklift Interface Kit (HIK) designed and fabricated by the Transport Technology Division of Blair International, Durham, England. Testing was performed at the U.S. Army Human Engineering Laboratory Combat Service Support Division Logistics Technology Test Site, Aberdeen Proving Ground (Edgewood Area), MD.

ACKNOWLEDGMENTS

The author of this report wishes to express his sincere thanks and appreciation for the technical assistance provided by Mr Ken Reynard, formerly of the Blair International Corporation, Durham, England, and now President, Reynard Engineering, Ltd, England and Mr Dudley Loveland, President, Westlake, Inc., Farmingdale, NJ, the developers of the HIK. Their on-site and off-site technical support facilitated the uninterrupted conduct of the field trials, and the early dissemination of the results through the publication of this report.

The author also wishes to extend his thanks and appreciation to Mr John J. Salser, the U.S. Government Principal Investigator and SSG Darrell Cumpton, U.S. Government Associate Investigator whose advice and counsel were of inestimable value to the work performed under this task. Both individuals were at the field test site during the preparation for and the conduct of the entire test and provided "hands on" technical guidance and support during every phase of activity.

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INTRODUCTION

The results of a 1984 worldwide survey of container ports, as reported in Janes' "Freight Containers International Survey of Containers", listed over 350 ports scattered throughout the world that have, or were in the process of constructing container handling facilities. The introduction of round-the-world super ship services during this same period using new large container ships and cargo ships converted to container vessels was the final event needed to assure the general cargo shipping industry that containers would dominate future transoceanic shipping. During the past five years, this rapid growth trend has continued. Today, container lifting, handling, and transporting equipment dominates the cargo handling operations of practically all major ports throughout the world. These facilities are continuously being upgraded by adding more and larger Gantry cranes with increased capacities and by interfacing this equipment with intermodal transport systems to provide a ***seamless distribution system.***

The United States shipping industry currently estimates that more than 80 percent of the general cargo being shipped to overseas ports is containerized. All new general cargo ships being built today are designed for the transport of containers and most of the older break-bulk cargo ships have been converted to transport containers. It is recognized by the military that, in the event of a future mobilization, the bulk of military equipment will, through necessity, be containerized. Oversize military cargo unsuitable for containerization will normally be transported by special military vessels or will be transported in the forward bay of a container ship. This bay will typically be of limited capacity. Upon arrival at a port, the noncontainerized, large items such as large trucks and heavy tracked vehicles will be handled "off line" from the primary cargo handling systems. The capabilities of most major ports to handle noncontainerized cargo will be limited, therefore, delays in handling such cargo will be the norm.

In recognition of the above, the military services have performed a number of studies to determine the available and applicability of ANSI ISO containers for the transport of military materiel. One of the most, if not the most, critical commodities in any war is ammunition. As the old adage goes, "a man on the battlefield can survive for weeks without food; he can survive days without water; but he cannot survive for one minute without ammunition".

Based on anticipated ammunition requirements in support of a major AirLand Battle, Future type conflict, it is estimated that the current inventory of military containers would be totally committed prior to the end of the first week of mobilization. At this point,

the military would be forced to rely on the private sector to provide the containers required for the uninterrupted movement of military supplies and equipment to the theater of operations.

A recent study (1987) performed by the U.S. Department of Transportation Research and Special Projects Administration Transport Systems Center identified the number of 8' x 8 1/2' x 20' ANSI ISO containers that may be expected to be available for the transport of ammunition at any one time during any future period of mobilization. These studies have also identified the advantages of shipping military cargo in containers. For example, minimizing pilferage enroute and reducing the number of times cargo has to be loaded and unloaded from point of origin to point of final destination are considered significant advantages. It is recognized that the fewer times cargo must be loaded and unloaded and the faster it can be moved to its final destination; the greater will be the savings in manpower associated with the logistical operations.

Having established the fact that in the event of any future major military conflict overseas, containers must be used for the movement of military materiel, ways must be found so that military equipment used for the movement of supplies and equipment is designed to be intermodally compatible with the private sector handling and movement equipment. It is also important that one other critical point be fully understood. Based on the amount of military supplies and equipment to be moved in containers, in relation to the extremely limited quantity of special military containers such as the MILVANS, it is obvious that during any major conflict, commercial ANSI ISO containers will be required beginning the first week of mobilization and continuing throughout the period of warfare.

Military and commercial containers used by the military must be capable of being moved by commercial cargo handling equipment and should fit into the cells of container ships. They should be capable of being stacked one on top of another in the ships container cells. It is also highly desirable that the military vehicles needed to interface with, and haul the military and commercial containers from the overseas ports forward, be compatible with the containers without the need for special equipment. The desired objective is a seamless intermodal transportation system.

BACKGROUND

The U.S. Army Human Engineering Laboratory (HEL), and the Project Manager, Ammunition Logistics (PM AMMOLOG) are in the process of evaluating soldier-equipment interfaces associated with the use of the Palletized Loading System (PLS) in the role of an ammunition carrier. HEL recently completed a series of field trials using an early Phase I design model of an ammunition container that is not only compatible with the PLS system but is also intermodally compatible with commercial handling equipment and container ships. It is called the Intermodal Ammunition Container (AMCON). NOTE: DUE TO ITS INTERMODAL COMPATIBILITY, IT IS ALSO REFERRED TO AS THE INTERMODAL CONTAINER (IMCON). A Phase II design with improved performance and weight-to-cargo ratio has been fabricated and is pending test by HEL. (Test is scheduled for January to March 1990 time frame.)

HEL and PM AMMOLOG have also successfully tested a Phase I design of a Hooklift Interface Kit (HIK). The HIK makes it possible to upload and download an ANSI ISO standard 8' x 8 1/2' x 20' container directly onto and off of a PLS vehicle without the use of a PLS flatrack and/or cargo handling crane or forklift. A Phase II improved design HIK has recently been fabricated and tested.

PURPOSE

The purpose of this document is to provide a brief summary of the results of the Proof of Principal field tests of the Phase I Design HIK and a more detailed report of the field testing of the Phase II Design HIK. NOTE: SUMMARY RESULTS OF THE PHASE I DESIGN EFFORT ARE PRESENTED BELOW TO PROVIDE THE READER WITH A COMPLETE KNOWLEDGE OF WORK PERFORMED ON THE HIK TO DATE IN A SINGLE DOCUMENT. FOR FURTHER INFORMATION ON THE TEST RESULTS OF THE PHASE I HIK, SEE ASI REPORT 88-16, "PROOF OF PRINCIPLE - INTERMODAL CONTAINER/HOOKLIFT INTERFACE KIT (IMCON/HIK)", DATED JANUARY 1989, ASI SYSTEMS INTERNATIONAL (AVAILABLE THROUGH THE USAHEL).

PART I - TEST RESULTS OF PHASE I DESIGN HIK

INTRODUCTION

A solution to the problem of interfacing military transport vehicles with containers came in the design of a device now known as the Hooklift Interface Kit or HIK. The HIK is made up of three subassemblies consisting of a cruciform and unipod with an approximate weight of 1100 lb, a pair of Container Guide Rails and a pair of Load Transport Rails weighing together approximately 1700 lb for a total weight of 2800 lb. The cruciform attaches to the four front corners of an ISO container and has a lifting bail that interfaces with the hook on the Load Handling System (LHS) of the Palletized Loading System (PLS). The Container Guide Rails are mounted on the rear portion of the frame of the PLS and are used to guide a container while it is being lifted onto the PLS without the use of a PLS flatrack. The Load Transport Rails are used to stabilize the load during transport once it is loaded onto the PLS. A locking device is also contained on the rear portion of each guide rail which, when locked into the two lower rear end corner castings of the container, provides further stability to the container while in transport. Photographs of these components are shown in Figures 1 through 4.

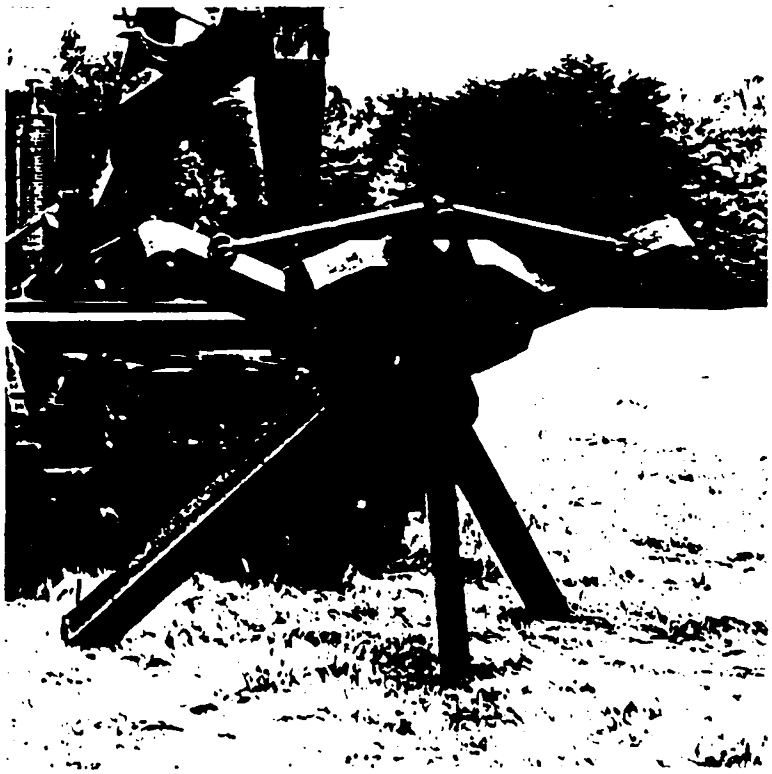

Figure 1. Cruciform with Unipod (Phase I)

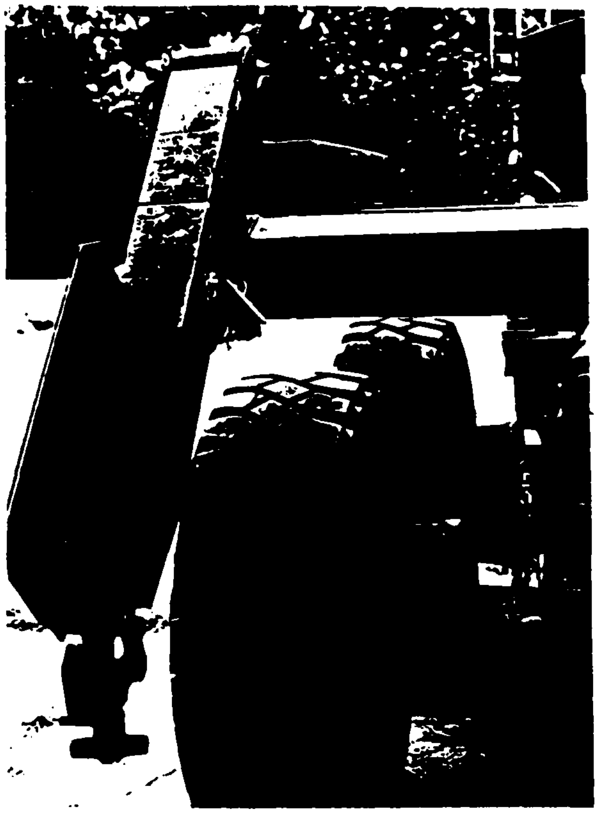

Figure 2. Container Guide Rail Subassembly (Phase I)

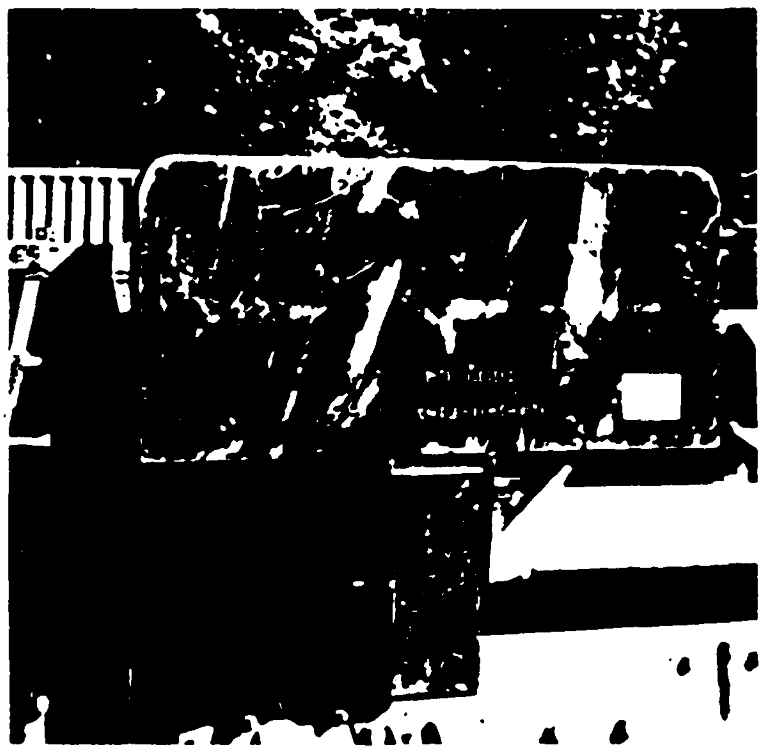

Figure 3. Load Transport Rail Subassembly (Phase I)

Figure 4. Phase I HIK on Palletized Loading System Vehicle

The use of a HIK to upload a fully loaded 8' x 8 1/2' x 20' ANSI ISO container and flatrack from the ground onto a PLS vehicle and to download the container from the PLS vehicle to the ground without the use of cranes or heavy fork lifts and without the use of a PLS standard flatrack was successfully demonstrated in limited Proof of Principle Field Tests. It was also successfully demonstrated that this same device could be used to upload and transport MED shelters on the PLS, thus providing a significant enhancement of the capabilities of the PLS when used as a transport vehicle. The mean time to pick up the cruciform from a ground storage mount with the hook of the LHS on the PLS, to connect the cruciform of the HIK onto a loaded commercial container, and to load the container onto the PLS was 7.46 minutes (2.53 minutes to backup the truck to the cruciform on-ground storage mount, pick the cruciform up with the LHS and store the cruciform on the PLS; and 4.93 minutes to attach it to a loaded commercial container and load and secure the container on the PLS vehicle). The mean time to download the container from a PLS truck, detach the cruciform from the container, and return the cruciform to the on-vehicle stowage position was 3.21 minutes (1.31 minutes to download the container from the vehicle to the ground and 1.90 minutes to detach the cruciform from

the container and return the cruciform to the on-vehicle stowage position). The mean time to remove the cruciform from the on-vehicle stowage position and place it on the ground storage unipod mount was 2.54 minutes. It was concluded that these times could be shortened further and a significant weight reduction could be achieved through minor changes in the Phase I design of the HIK.

SHORTFALLS/DEFICIENCIES

1. Shortfalls/Deficiencies of the Phase I HIK

Four shortfalls or deficiencies were identified with the use of the Phase I HIK:

a. The cruciform component of the HIK was heavier than required to overcome the stresses encountered in picking up a loaded ANSI ISO container. The weight was influenced by the requirement that the HIK be capable of picking up all sizes of containers from the 8 1/2' height to the half height container. Testing of the Phase I design prototype determined that this requirement is not practical. Since the great majority of ANSI ISO containers suitable for transport of ammunition are either 8' or 8 1/2' in height, it was recommended that the requirement for the Phase II design be amended to provide the capability to pick up containers of these heights only, plus the 6' high Ammunition Container (AMCON) presently under development.

b. Testing indicated that the lengths of the Container Guide Rail subassemblies of the HIK may have been longer and heavier than required. It was also concluded that a significant simplification of design and weight savings could be achieved by having the Container Guide Rails slide in a receiver from a ready position to an on-vehicle storage position rather than folding into an on-vehicle storage position. This redesign would also eliminate a rather serious potential safety hazard of crushing operators fingers when folding the guide rails from a "ready" to a "storage" position and removing the Load Transport Rail subassembly and storing it someplace on the vehicle. The proposed redesign would also eliminate the necessity of completely removing the top portion of the Load Transport Rail subassembly in order for the PLS to be capable of transporting the standard PLS flatrack. (EXPLANATORY NOTE: IN ORDER FOR THE PLS TO HAVE THE CAPABILITY OF TRANSPORTING THE PLS FLATRACK, THE TWO HIK CONTAINER GUIDE RAIL SUB-ASSEMBLIES WERE REQUIRED TO BE FOLDED INWARD TOWARDS THE CENTER OF THE REAR OF THE VEHICLE, AND THE TOP PORTION OF THE LOAD TRANSPORT RAIL SUBASSEMBLY REMOVED AND STORED

ELSEWHERE ON THE VEHICLE. THIS CONVERSION REQUIRED TWO MEN AN ESTIMATED EIGHT TO TEN MINUTES TO COMPLETE AND SINCE IT INVOLVED LIFTING, REMOVING PINS, FOLDING THE GUIDE RAILS AND REINSERTING PINS; IT OFFERED A FAIRLY HIGH PROBABILITY OF INJURY IN TERMS OF CRUSHED FINGERS WHEN THE COMPONENTS WERE BEING LIFTED AND FOLDED.)

c. Because of the small separation distance between the outer edge of the ANSI ISO container and the outside guide rails on the rear component of the HIK, the vehicle driver was required to closely align the vehicle with the container in order to upload it. Otherwise the bottom of the container may ride over the top edge of the vertical side portion of the guide rail. This sometimes became a time consuming operation depending on the skill of the driver. If not corrected, this could damage both the container and the guide rail. It was determined that by placing a slight outward flair of approximately two inches on the guide rails and slightly increasing the horizontal distances between right and left rails, the close alignment of the vehicle with the container would not be as critical.

d. The manual procedure for locking the cruciform to the lower corner castings of a container tended to be time consuming. It was determined that the time to perform this operation could be reduced and the procedure simplified by the addition of either an automatic air or hydraulic locking system operated by the driver from within the vehicle cab.

In addition to the design deficiencies mentioned above, several operational options were presented for consideration by the Government in the design of future prototypes of the HIK.

2. Operational Options

a. Option 1: Retain the cruciform and the rear mount HIK components on the PLS vehicle.

Advantages:

No prior decision relative to the type of mission to be performed is necessary. Without time delay (time required to move the cruciform from its on-vehicle stowage position and place it on the hook of the LHS or vice versa), the PLS vehicle would be capable of picking up either a standard PLS flatrack, an Intermodal AMCON, or an ANSI ISO container.

Disadvantages:

(1) An on-board crane would be required to lift the cruciform from its stowage position to the "ready" position. (EXPLANATORY NOTE: SOME OF THE CURRENT PLS PROTOTYPE VEHICLES UNDERGOING TESTING ARE EQUIPPED WITH AN ON-BOARD CRANE.)

(2) The load carrying capacity of the vehicle would be reduced by the weight of the HIK (approximately 2800 lb for the Phase I design) plus the weight of the on-board crane.

(3) A modification of the vehicle would be required to provide for a longer chassis to accommodate both the on-board crane and stowage room for the cruciform. Additionally, these design changes could impair the vision of the driver through the rear window due to the location of the HIK and ancillary crane. NOTE: UNDER THE PHASE II DESIGN EFFORT, STORAGE OF THE CRUCIFORM ON THE PLS WAS DETERMINED NOT TO BE A PRACTICAL ALTERNATIVE.

(4) The Phase I Design HIK ancillary components mounted on the rear portion of the vehicle would have to be designed with a fold-away capability or some type of sliding arrangement provided in order to provide proper clearance so that the standard flatrack could be picked up. The width of the sliding surfaces of the rear mount on which the ISO container rests would be restricted to approximately 5 1/2 inches to provide proper clearance for uploading/downloading the standard flatrack when the rear mount is in a folded position. The container guides, when in the folded position, may protrude beyond the rear vehicle mud flaps which could contribute to the problem of misalignment of the PLS and flatrack (or the PLS and ISO container) during uploading operations.

(5) This design change may also necessitate building the rear rollers into the horizontal cross beam which would be prone to build-up of mud restricting the free operation of the rollers.

b. Option 2: Only the rear components of the HIK will be mounted on the PLS vehicle. The cruciform will be stored at the unit motor pool.

Advantages:

(1) A weight savings of approximately 1100 lb would be achieved by the selection of Option 2 over Option 1. This would result in a greater load carrying capacity for the vehicle.

(2) When stored in the upright position (with the use of a single pedestal unipod), the cruciform can be picked up directly by the hook of the lifting mechanism on the PLS thus avoiding the necessity for an on-board crane.

Disadvantages:

(1) Some loss of load carrying capacity and flexibility would be experienced but not as great as with Option 1.

(2) The Phase I Design HIK ancillary components mounted on the rear portion of the vehicle would have to be designed with a fold-away capability or some type of sliding arrangement provided in order to provide proper clearance so that the standard flatrack could be picked up. The width of the sliding surfaces of the rear mount on which the ISO container rests would be restricted to approximately 5 1/2 inches to provide proper clearance for uploading/downloading the standard flatrack when the rear mount is in a folded position. The container guides, when in the folded position, may protrude beyond the rear vehicle mud flaps which could contribute to the problem of misalignment of the PLS and flatrack (or the PLS and ISO container) during uploading operations.

(3) This design change may also necessitate building the rear rollers into the horizontal cross beam which would be prone to buildup of mud restricting the free operation of the rollers.

c. Option 3: Both the HIK rear vehicle components and the standard PLS rear vehicle roller components are interchangeable. The standard rear rollers used on the PLS vehicle and/or the cruciform and rear vehicle HIK components will be stored in the unit motor pool. If the PLS vehicle is planned to be used to move flatracks, the standard roller components will be placed on the vehicle prior to the start of a mission. If the vehicle is to be used to transport ISO containers, the HIK components will be mounted on the

vehicle prior to start of the mission. Under this option, the rear rollers and the HIK rear-of-vehicle components would be designed so that either or both could be clamped into place either hydraulically or by air service on the truck. It is estimated that approximately 15 minutes would be required to perform this function.

Advantages:

(1) This option would provide a greater vehicle load carrying capacity than either Option 1 or Option 2. Under this option, the cruciform would be stored in the unit motor pool with the rear-of-vehicle components until needed.

(2) Both rear components of the HIK could be combined as one piece to provide more rigidity as well as a reduction in weight.

(3) The interchangeability of the roller components would eliminate the potential problem of fouling the flatrack on the HIK components mounted on the rear of the vehicle which sometimes occurred with the Phase I design . NOTE: WITH THE PHASE II DESIGN, THE TRUCK MOUNTED COMPONENTS OF THE HIK REMAIN ON THE PLS AT ALL TIMES AND ARE SIMPLY CHANGED TO A STORAGE MODE WHERE THEY DO NOT INTERFERE WITH THE STANDARD PLS FLATRACKS WHEN THEY ARE TRANSPORTED ON THE PLS.

Disadvantages:

Conversion of the PLS from a PLS Flatrack transport mode to a container transport mode would require the vehicle to return to the motor pool and would result in operational delays. This alternative was determined to be operationally infeasible.

3. Conclusions:

a. Based on Proof of Principal testing of the Phase I prototype of the HIK, it is feasible to use a HIK as an enhancement to the PLS for uploading, transport, and downloading of ANSI ISO commercial containers.

b. Use of the HIK will provide a significant increase in performance capabilities of the PLS by making it possible for the PLS to upload, transport, and download any of the worldwide inventory of over two million 8' x 8' x 20' and 8' x 8 1/2'

x 20' ANSI ISO containers as well as a number of military special purpose containers to include MILVAN, MED shelters, and possibly communication shelters.

c. The design of the cruciform component of the HIK to provide a capability to pick up half height as well as full height containers is not practical because the center of gravity of the cruciform is changed when picking up half height containers which precludes locking of the cruciform to the end corner castings of the container.

d. The overall weight of the cruciform can be reduced by use of lighter type materials such as aluminum or composites and by changing the sliding mechanisms for the upper arms of the cruciform to restrict adjustment to the 8' and 8 1/2' high containers as discussed in paragraph c above.

e. The design of the rear components of the HIK is unnecessarily complex due to the necessity for the outer ends to fold inward towards the center of the rear of the PLS vehicle (to reduce protrusion behind the rear of the vehicle) and for the entire rear component to fold outward towards the side and down so that it won't interfere with picking up the PLS flatrack.

f. The length of the rear guide rail components of the HIK can be shortened without hampering the performance capability. This will not only reduce the weight but should also simplify the design by eliminating the necessity for the rear ends of the guide rails to be folded inward. NOTE: ONE REASON FOR THE PRESENT LENGTH IS TO ASSURE THAT WHEN PICKING UP A TYPICAL COMMERCIAL CONTAINER, AT LEAST THREE OF THE CROSS MEMBERS ON THE BOTTOM OF THE CONTAINER WILL BE RESTING ON THE SIDE LOADING RAILS OF THE CONTAINER GUIDE RAIL SUBASSEMBLY AT ALL TIMES. THIS IS AN ADDED SAFETY FEATURE TO PREVENT POSSIBLE DAMAGE TO AN ISO CONTAINER THAT MAY HAVE BEEN WEAKENED DUE TO LONG TERM USAGE.

g. The small separation distance between the outer dimensions of the rear vertical guide rails and a standard 8' wide container is not warranted in view of the recent change that would permit 8 feet 2 inches wide commercial refrigerated containers to be transported on European highways. The separation between guide rails should be increased by 1 to 2 inches in order to minimize the difficulties of uploading commercial containers onto the PLS.

h. The current procedure for mechanically locking the bottom two legs of the cruciform onto the bottom two corner castings of a commercial container can be simplified by the addition of an automatic air or hydraulic system operated by the driver of the PLS from within the vehicle cab.

4. Recommendations: The Phase I test report contained recommendations for design changes to correct the above deficiencies. It was also recommended that consideration by given to designing the "A" frame with a bail bar used on the PLS flatracks as an integral part of future Medical, Maintenance and possibly Communication shelters in the future so they can be uploaded, transported, and downloaded by the PLS without using the HIK. The ultimate design feature would be to include the NATO standard rails on the base of such containers the same as the rails used on the current PLS flatrack, so that containers could be picked up and transported directly by the PLS without the use of any the of HIK components. It is recognized however that although the military services can influence the design of special military containers, they would have a difficult time influencing this type of design change to the millions of commercial containers used by the private sector throughout the world.

PART II - TEST RESULTS OF PHASE II DESIGN HIK

OBJECTIVE

The objectives of the test were as follows:

1. Gather soldier-equipment interface field test data as input to validate the design principle, the operational feasibility of using a Phase II Design Hooklift Interface Kit mounted on a PLS truck to upload and download standard ANSI ISO containers loaded with ammunition without the use of the standard PLS flatrack; and to determine compatibility with the PLS truck when used as part of the PLS system for the movement of ammunition.

2. Generate a limited amount of experimental test data including "times of completion" for the tasks indicated above for presentation to the users in order to determine whether or not there is a requirement for a HIK to be used for the uploading, downloading and movement of unmodified ANSI ISO containers loaded with ammunition when used in the intermodal movement of ammunition. The "times to complete tasks" data collected during the timed trials will be of less importance in comparison with the primary objective stated in paragraph 1 above.

METHODOLOGY

1. Test Participants: Test Participants (TP) consisted of military and civilian personnel assigned to HEL, with technical support being provided by on-site ASI Systems International (ASI) project personnel.

2. Test Procedures: All TP were trained in the operation of the PLS vehicle and were given a thorough briefing and demonstration on the operation of the items to be tested. Prior to the timed trials, they were given detailed instructions including the objective of the test, and the procedure for executing the trial. Each driver and assistant driver participated in a limited number of "dry runs" to be sure they understood the procedure prior to conduct of the timed trials.

3. Test Location: Tests were conducted at the HELFAST Logistics Technology Test Site, Edgewood Area, Aberdeen Proving Ground, MD.

APPARATUS

1. Equipment Used in the Test: The following equipment was used in support of the Test:

a. PLS vehicle
b. Experimental Hooklift Interface Kit (HIK Phase II Design)
c. 6000 lb Rough Terrain Fork Lift (RTFL)
d. 4000 lb Rough Terrain Fork Lift (RTFL)
e. Palletized dummy ammunition
f. Stop watches
g. NATO standard cargo restraint straps

2. Precision of Equipment: All equipment used in the test was examined before hand to assure it was in satisfactory operating condition.

3. Safety Features of Equipment: All equipment used in the test with the exception of the experimental Phase II HIK and PLS were standard items which have been previously tested and safety certified. An item of similar design to the HIK was successfully demonstrated by the developer to the British Army. This demonstration was witnessed by senior US military personnel. Within the past year, HEL procured and tested a Phase I HIK without incident . The PLS vehicle used in the HEL Phase II HIK tests was previously used in military tests at Ft Hood, TX and was safety certified at that time.

DESCRIPTION OF EXPERIMENTAL TEST ITEMS

The Phase II HIK consists of three components: a cruciform with a unipod ground stowage mount, a pair of Container Guide Rail subassemblies to be mounted on the right and left sides of the rear of the frame of the PLS, and a pair of Load Transport Rail subassemblies mounted forward of the right and left side Container Guide Rails. The Container Guide Rail subassemblies and the Load Transport Rail subassemblies are bolted to the rear portion of the PLS vehicle frame. The cruciform is stored on the ground by use of a unipod. When carried on the vehicle, the cruciform is stored on the lifting hook of the PLS Load Handling System (LHS). Figures 5, 6, and 7 are photographs of the Phase II Container Guide Rail subassembly, the Load Transport Rail subassembly and the

Cruciform. Figure 8 is a photograph of the PLS with the HIK in the process of uploading an ANSI ISO container of ammunition.

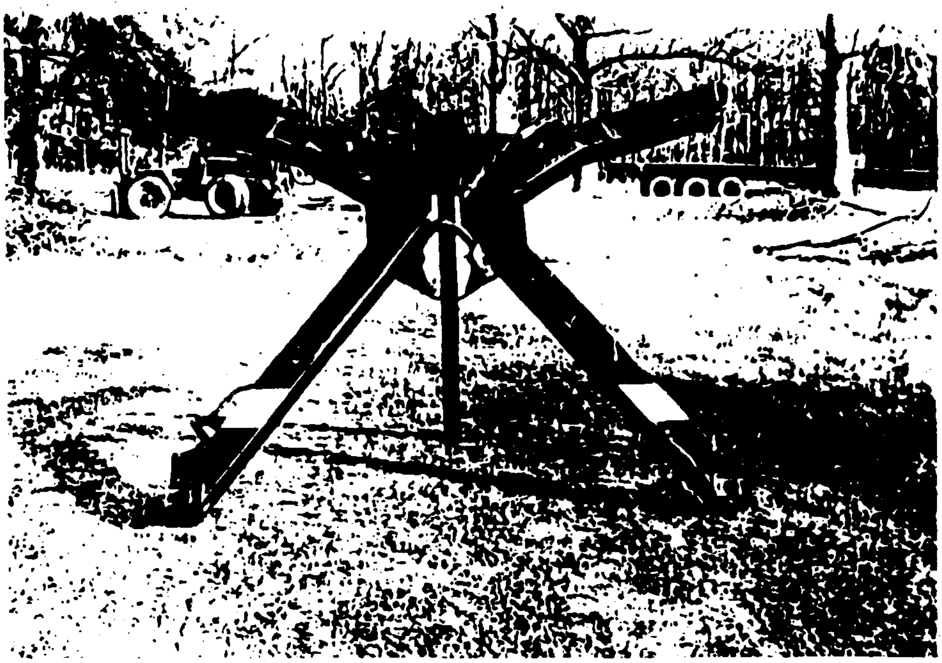

Figure 5. Cruciform with Unipod (Phase II)

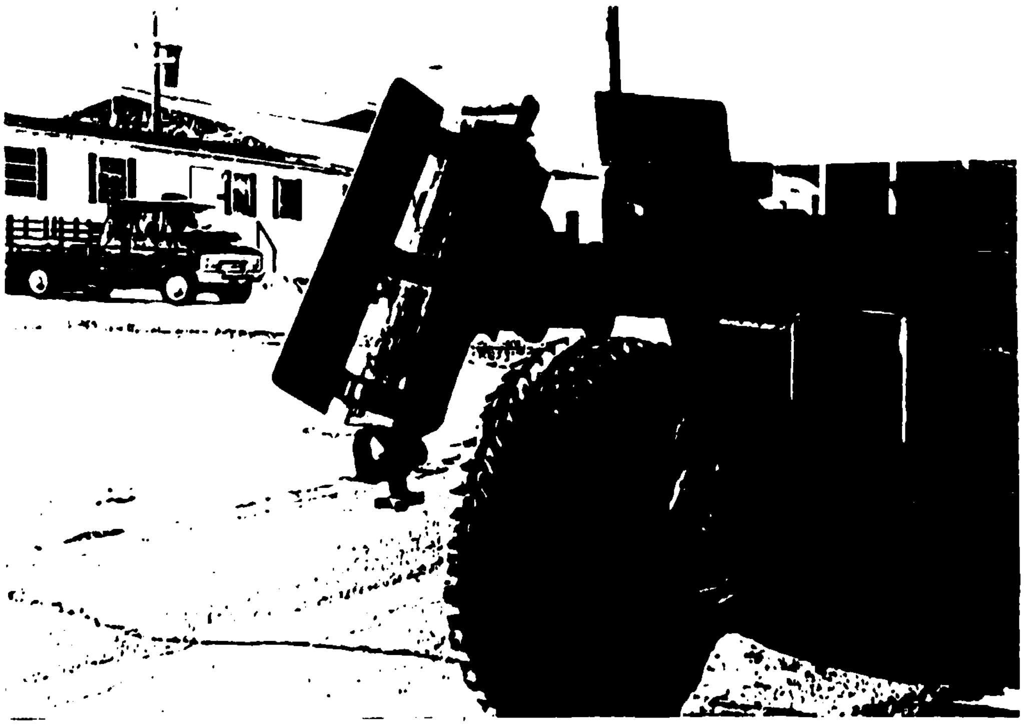

Figure 6. Container Guide Rail Subassembly (Phase II)

Figure 7. Load Transport Rail Subassembly (Phase II)

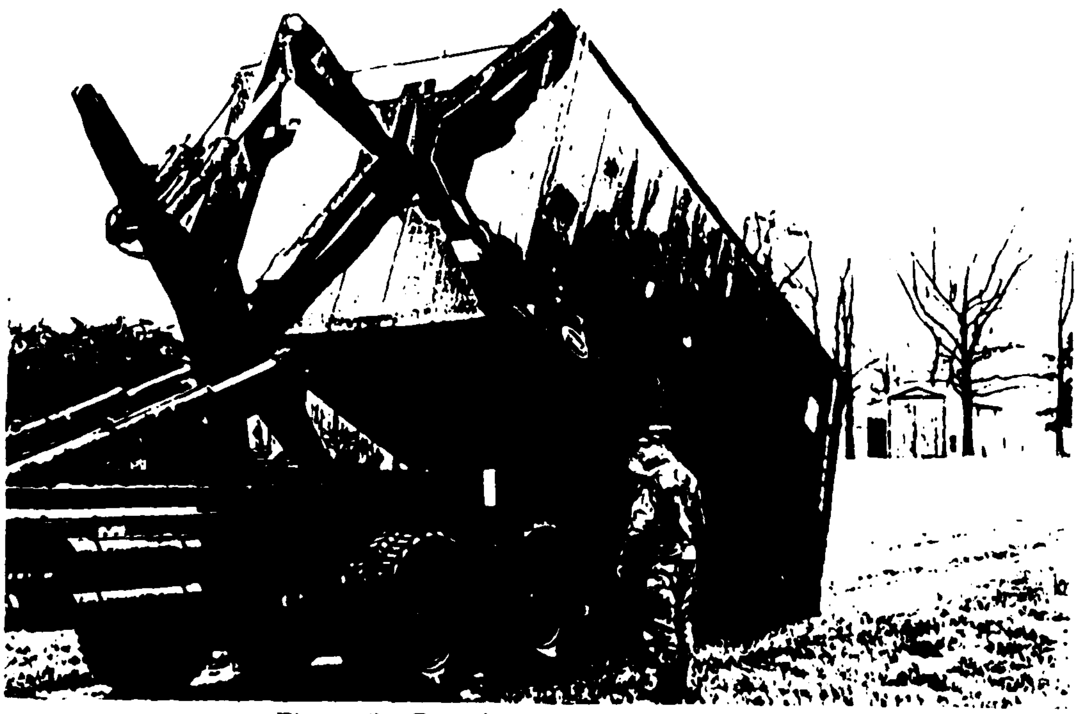

Figure 8. Container Upload (Phase II HIK)

COMPARISONS OF PHASE I VERSUS PHASE II HIK

Size:

The overall height of the Phase II Load Transport Rail subassembly is 13" and the width is 5", the same dimensions as the Phase I design.

The overall height of the Phase I Container Guide Rail subassembly was 13" and the overall length 58". The height of the Phase II Container Guide Rail subassembly is 16" with an overall length of 46". (This reduction in length facilitated the redesign of the Phase II subassembly by eliminating the need to have it fold inward towards the center of the truck as was required with the Phase I design in order to reduce its protrusion beyond the rear of the truck.)

The overall width of the horizontal portion of the Phase II guide rails on the Container Guide Rails is 8" as compared with 6" with the Phase I design. The reason for the increase was to provide a greater margin of safety to preclude a container from slipping off the inside of the guide rail in the event it may not have been perfectly aligned with the guide rails as it was being uploaded or downloaded.

Weight:

The Phase I HIK weighs a total of 2800 lb as compared with the total weight of the Phase II HIK which weighs 2112 lb. This represents a weight savings of 25 percent.

On-vehicle Storage:

The Load Transport Rail subassemblies of the Phase I design could not be stored on the vehicle when it was converted from the ISO container transport mode to the flatrack mode. The top half of the Load Transport Rail components had to be removed and stored elsewhere. On the Phase II design, the top half can be folded inward by pulling one pin and reinserting it when the component has been folded into position so that the regular flatrack can be loaded onto the PLS without removing the Load Transport Rail subassembly.

Container Guide Rails:

On the Phase I model, two men were required to first fold the top half by pulling two pins and folding it inward. They were then required to pull an additional pin and fold the rear half of the mechanism in towards the center of the vehicle and reinsert the

pin. This was a dangerous operation as it provided numerous opportunities for pinched fingers while performing both folding operations.

On the Phase II design, changing from the container operational mode to the flatrack transport mode is accomplished as a sliding action rather than a folding and lifting action. One person pulls two pins while the other slides the top mechanism forward resting it on a metal plate attached to the Load Transport Rail subassembly. The Container Guide Rail subassembly is then rotated downward by the use of a 24" long pipe. (See Figure 9).

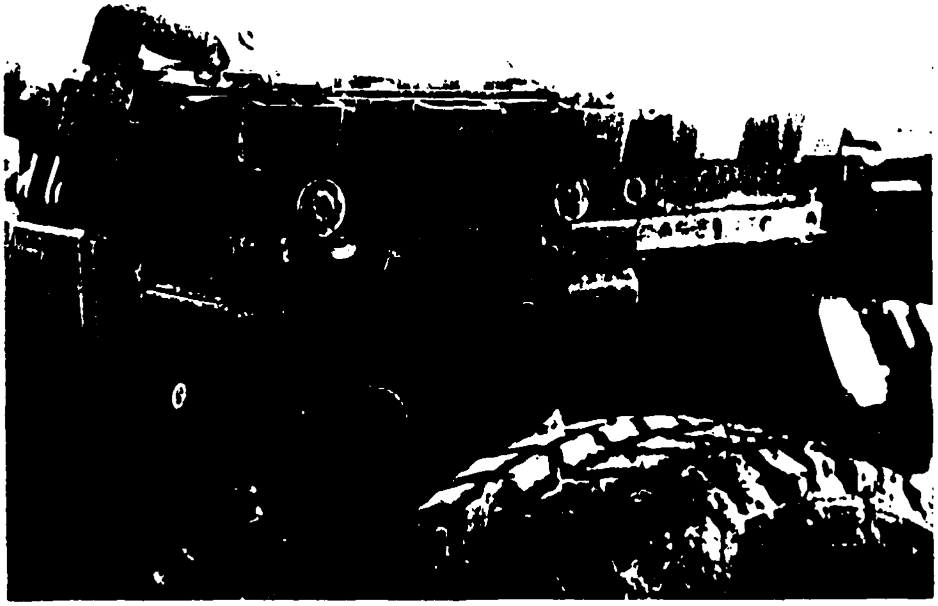

Figure 9. Container Guide Rails in Storage Position (Phase II)

Due to safety hazards, time trials for converting the components from ISO container carrying configuration to a flatrack transport configuration were never conducted on the Phase I design. It was estimated, however, that this conversion required approximately 10 minutes to accomplish. Time trials were run with the Phase II design and the mean time to perform this function was only 1.90 minutes. See Table 3.

DESCRIPTION OF TEST LAYOUT

1. Field Layout of Equipment for Testing the HIK: Figure 10 is a schematic of the HELFAST Human Engineering Laboratory Logistics Test Site which includes equipment layout for conduct of the HIK field trials. Prior to start of the test, an ISO container was loaded with approximately 27,500 lb of palletized dummy ammunition with a gross weight

of approximately 33,000 lb (Figure 11). A single 2" x 4" pine wood brace was nailed on the floor immediately behind the two rear pallets to prevent them from sliding against the rear doors of the container during uploading and downloading onto and off of the PLS vehicle. The loaded container was grounded on one side of the dirt road and a cruciform on the ground mount was placed approximately 10 feet to the side of the container. A PLS vehicle with the flatrack removed was placed across the road approximately 30 feet in front of the container.

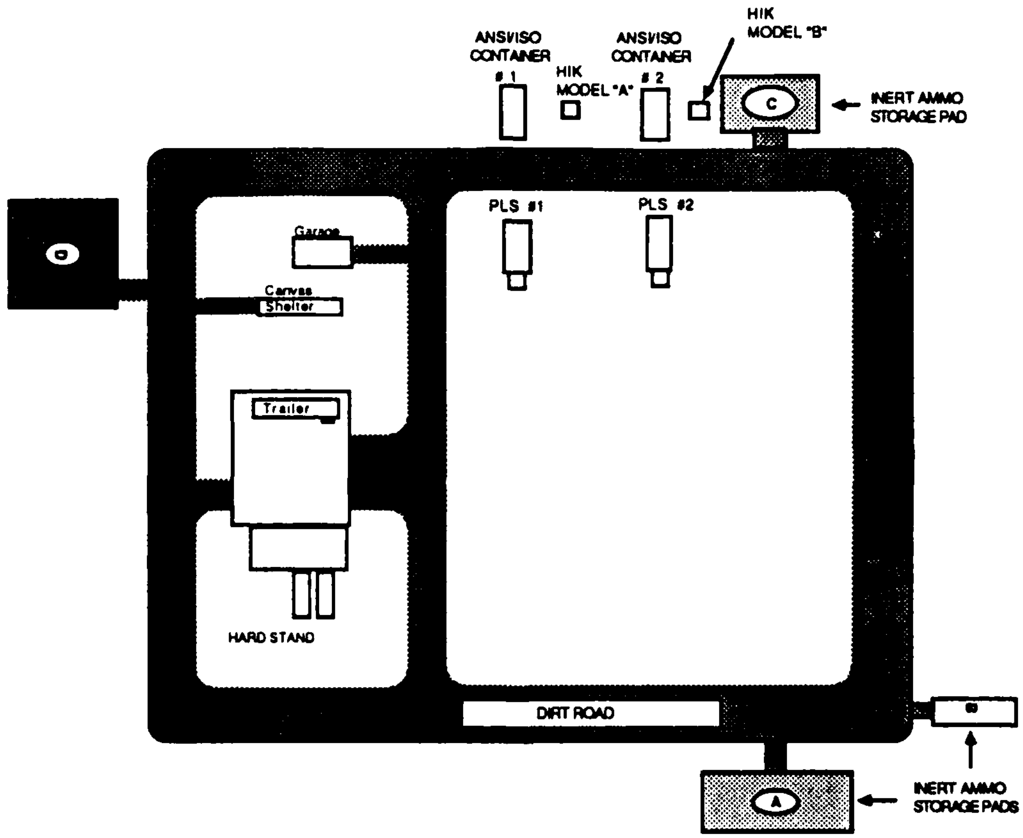

Figure 10. Field Test Layout

FRONT	.50 cal Ammo	105 mm Ammo (PA104)	.50 cal Ammo	.50 cal Ammo	REAR
	.50 cal Ammo	.50 cal Ammo	105mm Ammo (PA104)	.50 cal Ammo	

Figure 11. Container Loading Diagram

TEST OBJECTIVES AND ANALYSIS OF TEST RESULTS

1. Subtest #1 - Upload and Download Container

a. Objective: These time trials were conducted to determine the feasibility of uploading and downloading an ANSI ISO container loaded with ammunition onto and off of a PLS by the use of a Phase II design HIK and to determine the structural integrity of a typical commercial container loaded with approximately 27,500 lb of ammunition when uploaded and downloaded onto and off a PLS vehicle by use of the HIK. A secondary objective was to obtain preliminary information on approximate times required to complete each of the subfunctions involved in uploading and downloading the container.

b. Procedure: Each trial was divided into four subfunctions as follows:

(1) Subfunction 1 - Pickup Cruciform from Unipod Ground Storage Position and Store on the Load Handling System (LHS): The driver and assistant driver were both located inside the PLS vehicle. On signal from the time keeper, the assistant driver dismounted from the vehicle, moved to the location of the cruciform and used hand signals to direct the driver to backup the truck and pickup the cruciform. When the hook of the LHS was engaged and the cruciform lifted approximately 6" off the ground, the assistant driver unhooked the unipod and placed it on the ground while the driver used the LHS to move the cruciform to the on-vehicle storage position. "Time Stop" was recorded when the cruciform was in the on-vehicle storage position.

(2) Subfunction 2 - Attach Cruciform to Container and Upload Container onto the PLS: On signal from the time keeper, the assistant driver, using hand signals, directed the vehicle to within 1 to 2 ft in front of the container. The driver lowered the cruciform and then, following hand signals from the assistant driver, slowly backed the vehicle towards the container until the cruciform was engaged into the four corner castings on the front of the container. The assistant driver then secured the two lower connectors and signaled the driver to load the container. As the container was being lifted onto the PLS, the assistant driver observed the progress to be sure the container was fitting between the outside vertical plates of the two Container Guide Rail subassemblies. When the container had been uploaded, the assistant driver engaged and secured the two locking fixtures into the bottom two corners on the rear of the container. He then mounted the

vehicle. "Time Stop" was recorded when the assistant driver entered the cab and the vehicle began to move forward.

(3) Subfunction 3 - Download Container from PLS and Detach Cruciform: Upon signal from the time keeper, the assistant driver dismounted the vehicle and disengaged the two locking fixtures from the lower corner castings of the container. Using hand signals, he directed the driver to download the container. When the container was on the ground, the assistant driver unlocked the two lower connectors of the cruciform from the container and signalled the driver to move forward to disconnect the cruciform. "Time Stop" was recorded when the cruciform was free of the container.

(4) Subfunction 4 - Remove Cruciform from PLS and Store on Ground: Upon signal from the timekeeper, the driver will pull forward and stop. The assistant driver will hook the unipod into the cruciform and signal the driver to lower the cruciform to the ground. "Time Stop" will be recorded when the hook of the LHS clears the unipod, the LHS is in the on-vehicle stowage position, and the vehicle begins to move forward.

c. Test Results: Tables 1 and 2 show the times required to perform each of the subfunctions described above. The mean times and standard deviation are shown at the bottom of each table.

Table 1. Cruciform Upload and Download

(Times in Minutes)

TRIAL	PICK-UP AND STORE CRUCIFORM ON PLS	REMOVE CRUCIFORM FROM PLS AND STORE ON GROUND
1	3.12	2.72
2	2.92	2.28
3	2.68	2.25
4	2.08	1.82
5	2.72	2.55
6	2.38	2.22
7	2.75	1.97
8	2.55	2.40
9	2.48	1.90
10	2.68	2.63
11	2.30	1.90
12	2.42	2.32

ATTACH AND STORE CRUCIFORM ON PLS
Mean = 2.59 Standard Deviation = .28

DETACH AND STORE CRUCIFORM ON GROUND
Mean = 2.25 Standard Deviation = .30

Table 2. Container Upload and Download - Phase II HIK

(Times in Minutes)

TRIAL	SECURE CRUCIFORM ON CONTAINER AND UPLOAD	DOWNLOAD CONTAINER AND DETACH CRUCIFORM	TOTAL TIME
1	1.73	1.77	3.50
2	3.15	1.68	4.83
3	3.82	1.92	5.74
4	2.10	1.00	3.10
5	2.97	1.78	4.75
6	3.75	2.63	6.38
7	2.55	1.38	3.93
8	3.10	1.42	4.52
9	3.83	1.28	5.11
10	2.38	1.33	3.71
11	2.78	2.05	4.83
12	4.25[1]	1.53	5.78
13	2.82	1.10	3.92
14	2.82	2.28	5.10
15	2.73	2.92	5.65
16	4.37[2]	1.82	6.19
17	3.00	1.28	4.28
18	3.47	1.07	4.54
19	3.83	1.43	5.26
20	3.30	1.20	4.50
21	3.15	1.30	4.45
22	3.48	1.18	4.66
23	3.23	1.02	4.25
24	2.65	1.62	4.27

Secure Cruciform on Container and Upload on PLS
Mean: 3.14 Standard Deviation: .65

Download Container onto Ground and Detach Cruciform
Mean: 1.58 Standard Deviation: .50

[1] Hydraulics failed in automatic upload mode and would not pick-up the load. After two attempts, the driver switched the Load Handling System from Automatic (Position 1) to Manual Position. Once the container was partially loaded he switched to Manual Position 3 to complete the uploading of the container onto the PLS.

[2] Assistant driver had difficulty locking the twist lock of cruciform into lower right side of container casting. After third attempt, twist lock of left leg was released from container and the vehicle was moved forward approximately 6 inches. The vehicle was then reversed until both twist locks were seated in the container castings. The assistant driver was then able to lock both twist locks into the container corner castings without further difficulty.

Note: The times shown for trials 12 and 16 were included in computation of mean and standard deviation.

The observed time to backup the PLS truck, lower the hook of the LHS from the on-vehicle stowage position to the ready-to-load position for the Phase I design was 2.53 minutes. As shown in Table 1, the observed time to perform this same function with the Phase II design equipment was 2.59 minutes which represents a 2.4 percent increase in time of the Phase II versus the Phase I design. Therefore the time to perform this function can be considered equal for both designs.

The time to secure the Phase I HIK to a loaded ANSI ISO container and upload it onto a PLS vehicle averaged 4.93 minutes. As shown in Table 2, the mean time to secure the Phase II HIK and upload a loaded ANSI ISO container onto a PLS vehicle was 3.14 minutes, which is a 36 percent savings in time of the Phase II design over the Phase I design.

The average time to download a loaded ANSI ISO container from a PLS truck to the ground and disconnect the cruciform from the container with the Phase I HIK was 3.21 minutes. As shown in Table 2, the average time with the Phase II HIK was 1.58 minutes which is a 51 percent savings in time. However, the procedure for downloading the Phase I design required the assistant driver to unlatch the locking device which locked the rear ends of the Container Guide Rails into the two bottom corner castings of the container. Since these locks were not operable on the Phase II design this function was not performed. Therefore the savings in time for the Phase I versus the Phase II is overstated. By simulating this unlocking motion it is estimated an additional 30 to 45 seconds would be required. This would raise the average time to perform the downloading function from 1.58 minutes to between 2.08 and 2.33 minutes which is a savings of between 35 and 27 percent.

As shown in Table 1, the mean time to detach the cruciform from the LHS and store it on the unipod ground mount was 2.25 minutes as compared with 2.54 minutes for the Phase I design or a savings of 11 percent.

d. Analysis of Test Results:

(1) Function: Lower the hook of the PLS from the upload to the download position, pick up the cruciform from the ground mount and raise the cruciform to the on vehicle storage position.

Analysis: Since the interface portion of the Phase I design and the Phase II design remained basically unchanged, and since the task represented a very simple

maneuver of the PLS vehicle and the LHS system, the similarity in times to pick up the Phase I cruciform and the Phase II cruciform was predictable.

(2) Function: Attach the cruciform to a container and upload the container onto the PLS.

Analysis: As indicated in Table 2 above, the mean time to perform this function with the Phase II HIK was significantly less than with the Phase I equipment. This savings in time is attributable primarily to a change in the design of the mechanism for locking the two lower legs of the cruciform into the front bottom corner castings of the container, the significant reduction in weight of the cruciform, and the simplification in design of the upper arms of the cruciform. [NOTE: PHASE I DESIGN WOULD ACCOMMODATE HALF HEIGHT AS WELL AS 8 AND 8 1/2' HIGH CONTAINERS. PHASE II DESIGN ACCOMMODATES CONTAINERS RANGING IN HEIGHT FROM 6' TO 8 1/2']. This change in requirement facilitated the simplification of the Phase II prototypes. With the Phase I design, the assistant driver had to move a lever which turned the twist lock from the vertical position to the horizontal position on the two lower legs of the cruciform . He was then required to turn a screw threaded bolt several times by hand and then tighten it by use of a hammer striking the four pronged twist bolt. (See Figure 12).

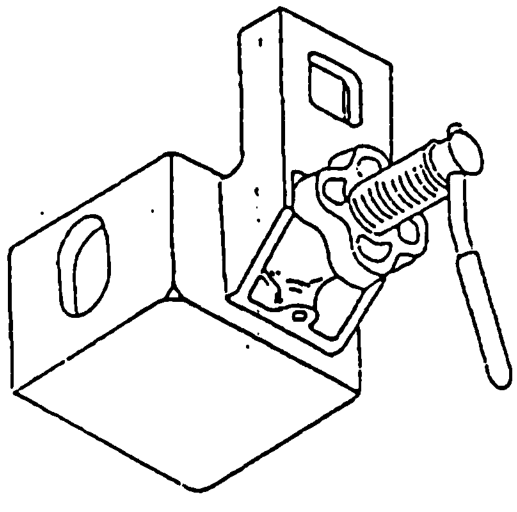

Figure 12. Twist Lock (Phase I)

For the Phase II design, the driver simply moved a hand lever from the horizontal position to the vertical position which activated a spring mechanism which, in turn, moved

the twist lock from the vertical to the horizontal position locking the cruciform onto the container. (See Figure 13).

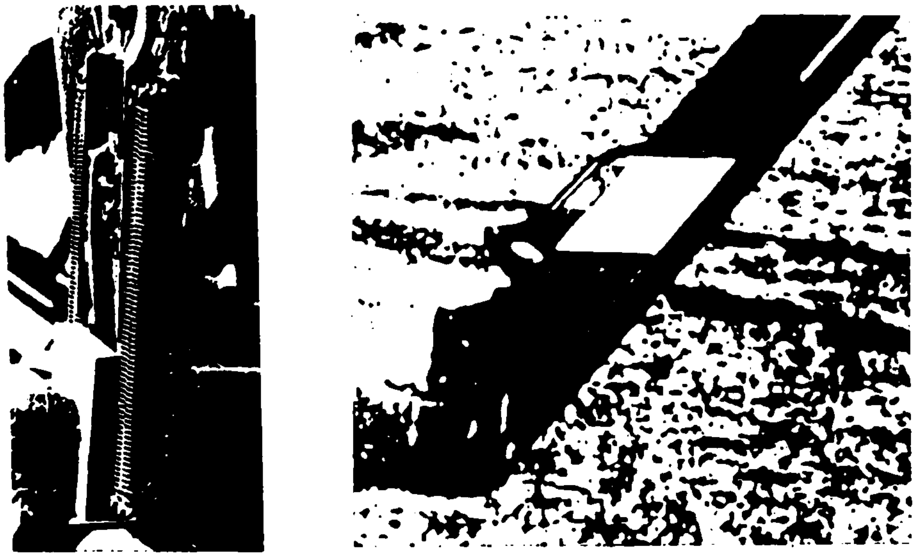

Figure 13. Twist Lock (Phase II)

During one of the trials, it was noted that, although the handle was moved to the locked position as discussed above, one end of the cruciform came loose from the container when the driver began to upload the container. The twist lock had remained in the vertical position, even though the handle had been moved to the locked position. For all future trials, the assistant driver was directed to get down on his knees and visually examine the twist lock inside of the corner casting to be sure it was completely turned from the vertical to the horizontal position before signalling the driver to upload the container.

One additional reason for the improvement in performance of the Phase II design in comparison with the Phase I design can be attributed to the fact that the Phase I design cruciform was required to pick up half height containers as well as full height containers. This necessitated the addition of a bail bar to be used in picking up the cruciform and attaching it to a container. This was necessary in order to change the center of gravity (CG) of the cruciform for attachment to the container. Once it was attached, the assistant driver was required to disconnect and remove this bail bar so that the driver could pick up the loaded container using the second, load lifting bail bar. Under the Phase II design, since the cruciform was no longer required to pick up half height containers, the necessity for the second bail bar was eliminated.

(3) <u>Function</u>: Download the container from the PLS vehicle and detach the cruciform from the container.

<u>Analysis</u>: This function is the reverse of function (2) above. As reflected in Table 2, the mean time to perform this function with the Phase II equipment was significantly less than the time required to perform the same function with the Phase I equipment. The primary reason for this reduction in time was due to the redesign of the release mechanism for releasing the lower two legs of the cruciform from the container.

The Phase I design required the assistant driver to loosen the screw type device used to lock each of the bottom two legs of the cruciform to the container, by first hitting it with a hammer for the initial release and then twisting the four pronged knob by hand to further release the pressure between the twist lock and the corner casting of the container. A bar type handle connected to the twist lock was then moved 90 degrees to change the twist lock from a horizontal to a vertical position which released it from the corner casting of the container. The assistant driver then signalled the driver to move forward and free the top and bottom legs of the cruciform from the container.

With the Phase II design, the four pronged knob with the screw type locking mechanism and the handle connected to the twist lock were replaced by a single bar type handle that operated a spring mechanism for turning the twist lock to the locked (or unlocked) position, and securing (or releasing) it from that position. One downward pull of the handle was all that was required to release the twist lock on each lower leg of the cruciform from the container.

Early in the testing cycle, the assistant driver was having difficulty in pulling the hand lever to unlock the container in some of the trials. A 1 1/2 inch diameter pipe approximately 2 1/2 feet long was slipped over the 5/8" diameter hand lever in order to apply more leverage on the handle. On the following trial, this caused the handle to break at the point of weld. Once it was rewelded, heavy grease was applied to the twist lock which facilitated its functioning in future trials. The use of the pipe extension was discarded and during subsequent trials when the lever could not be moved with ease, the driver moved the LHS mechanism either slightly upward or downward to eliminate the pressure between the corner casting of the container and the twist lock which freed the unlocking mechanism so it could be operated without the extension handle.

Upon observation of the test trials and close examination of the Phase II locking mechanism, it is believed that a simpler redesign is possible which will perform equally well if not better than the present design. If the current design is continued, a stronger

spring may be required to preclude malfunctioning as indicated above. Another possibility would be to slightly increase the tolerance between the twist lock and the sleeve that interfaces with the corner casting of the container as shown in Figure 14.

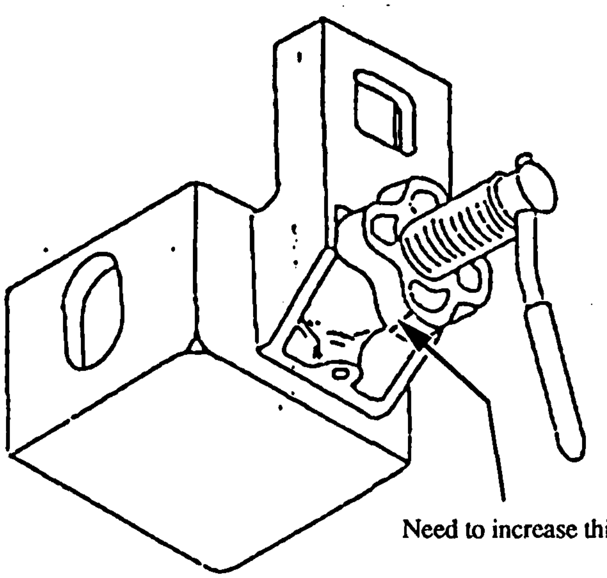

Figure 14. Required Twist Lock Improvement

Strengthening the handle, i.e, fabricating it from a single piece of metal rather than two pieces welded, and by adding approximately 12 to 18" to the overall length, would facilitate its operation and eliminate any future need to use an extension pipe to unlock the cruciform from the container when it may be slightly out of alignment.

(4) Function: Lower the hook on the PLS LHS from the on vehicle storage position to the upload position, detach the cruciform and store it onto the ground mount.

Analysis: Lowering the cruciform from the PLS and storing it on the ground was slightly faster in comparison to the function of attaching it and storing it onto the PLS because there was no need for the driver to align the truck with the cruciform on the ground mount, back up slowly until the hook of the LHS was directly under the bail bar used in picking up the cruciform before picking it up. In the lowering of the cruciform and storing it on the ground mount, the driver simply lowered the cruciform to the ground in a designated location and the assistant driver hooked the unipod to the cruciform which was then lowered until the hook of the LHS was disengaged from the cruciform.

The lighter weight of the cruciform and the redesign of the open end clamp for attaching the unipod to the cruciform for storage on the ground are additional factors that made it easier and faster to store the Phase II cruciform on the ground mount than was the case with Phase I.

Because of the safety hazards associated with the folding for storage and unfolding for operating the Phase I design of the two Container Guide Rail and Load Transport Rail subassemblies, no measurements of the time required to convert these subassemblies from their on-vehicle operational mode to the storage mode (or vice versa) were made. However, based on a visual observation, and discussions with the Test Program Manager and other test participants, the few times the Phase I design was changed from an on-vehicle storage position to an operational position it is estimated that the time to perform this function approximated 10 minutes.

The Phase I design required pulling two large pins from each of the two Load Transport Rail carrying subassemblies, removal of the top portion of the subassemblies and placement on the ground in order to use the PLS for uploading the standard flatrack. This required two individuals to complete the task. In order to convert the Phase I design Container Guide Rail subassemblies from an operational position to a storage position, two men were required to pull two pins, fold the top portion of the subassembly 90 degrees in an outward direction and then reinsert the pins. This was followed by pulling a pin from the rear half of the subassembly and folding it approximately 45 degree inward, and then reinserting and securing a pin. This conversion was not only labor intensive and time consuming, but dangerous as well. Each folding operation provided numerous opportunities for crushing fingers. Conversion of the Phase II design, on the otherhand, was greatly simplified, less time consuming, and did not involve the safety hazards associated with the Phase I design.

Although not listed in the Phase II design test plan as one of the required functions to be tested, the Government Principal Investigator asked that a limited number of trials be run to determine the average time required to perform these conversion functions with the Phase II design. These trials, identified as Subtests #2 and #3, and test results are described in the following paragraphs:

2. Subtest #2 - Convert Vehicle-Mounted Container Guide Rails and Load Transport Rails from Storage Mode to Ready-to-Load Mode.

a. Objective: These time trials were conducted to determine the time required to convert the vehicle mounted Container Guide Rails and the Load Transport Rails from an on-vehicle storage mode to a ready-to-load mode.

b. Test Procedure: Each trial was divided into two separately timed subfunctions as follows:

(1) Subfunction #1 - Convert the Container Guide Rails from an on-vehicle storage mode to a ready-to-load mode. This was a two-man operation. On signal from the time keeper, one TP inserted a 2' long pipe into a male fixture in a drum shaped component on the rear of the Container Guide Rail and raised it slightly while the second TP pulled two pins from the top section of the guide rail, slid the mechanism approximately 12" to the rear and reinserted the pin into a second hole in the fixture. The second TP then rotated the drum in a counterclockwise position by pushing the pipe downward towards the ground while the first TP reinserted the second pin. The TP then proceeded to the opposite side of the rear of the PLS and performed the same function so that both Container Guide Rails were in an operational mode. Time Stop was recorded when the second pin on the second Container Guide Rail had been reinserted and locked into place.

(2) Subfunction #2 - Convert Load Transport Rails from an on-vehicle storage mode to a ready-to-load mode. This was a two-man operation. On signal from the time keeper one TP stood on either side of the PLS vehicle facing the Load Transport Rails. On signal from the time keeper, each TP simultaneously pulled a large locking pin from the Load Transport Rail subassembly They then grasped the top of the Load Transport Rail with both hands and pulled it forward towards their chest. When the Load Transport Rail was in the vertical position, the pin was reinserted and secured in a second hole which maintained the Load Transport Rail in an upright position. Time Stop was recorded when both fixtures were in the upright positions and the pins had been reinserted and secured.

c. Test Results: Table 3 shows the times required to perform each of the subfunctions described above. The mean times and standard deviation are shown at the bottom of the table for each subfunction.

Table 3. Conversion of the Container Guide Rails and Load Transport Tails from Storage Mode to Ready-to-Load Mode.

(Times in Minutes)

TRIAL	CONTAINER GUIDE RAILS (2)	LOAD TRANSPORT RAILS (2)	TOTAL
1	1.76	0.36	2.12
2	1.44	0.44	1.88
3	1.60	0.34	1.94
4	1.84	0.34	2.18
5	1.14	0.36	1.50
6	1.40	0.36	1.76

Container Guide Rail Mean =1.53 Standard Deviation = .26
Load Transport Platform Mean = .37 Standard Deviation = .26
Total Mean =1.90 Standard Deviation = .26

3. Subtest #3 - Convert the Container Guide Rails and the Load Transport Rails from a Ready-to-Load to the On-Vehicle Storage Mode.

a. Objective: These time trials were conducted to determine the time required to convert the vehicle mounted Container Guide Rails and the Load Transport Rails from an on-vehicle ready-to-load mode to the on-vehicle storage mode.

b. Test Procedure: The procedure for performing this function was simply the reverse of the procedure described under Subtest #2 above.

c. Test Results: Table 4 shows the times required to perform the two sub-functions described above. The mean time and standard deviation are shown at the bottom of the table for each subfunction.

Table 4. Conversion of Container Guide Rails and Load Transport Rails from Ready-to-Load Mode to Storage Mode
(Times in Minutes)

TRIAL	CONTAINER GUIDE RAILS (2)	LOAD TRANSPORT RAILS (2)	TOTAL
1	2.64	0.46	3.10
2	2.74	0.50	3.24
3	1.80	0.34	2.14
4	1.60	0.36	1.96
5	1.54	0.34	1.88
6	1.50	0.34	1.84

Container Guide Rail Mean = 1.97 Standard Deviation = .57
Load Transport Platform Mean = .39 Standard Deviation = .07
Total Mean = 2.36 Standard Deviation = .64

d. Analysis of Test Results: As shown in Table 3 the mean time to fold the two Container Guide Rail subassemblies and the Load Transport Rail subassemblies from the Storage mode to the Ready-to-Load mode was 1.90 minutes (1.53 + 0.37). As shown in Table 4, the mean time to unfold the two Load Transport Rail subassemblies and the Container Guide Rails from a storage mode to an operational move (the reverse of Table 3) was 2.36.

In performing the above functions, the test participants experienced minor difficulty in getting hold of the ends of the pins, especially when wearing gloves. See Figure 15. Substitution of some type of hand loop on the ends of the pins in place of the flat discs will readily correct this minor shortfall.

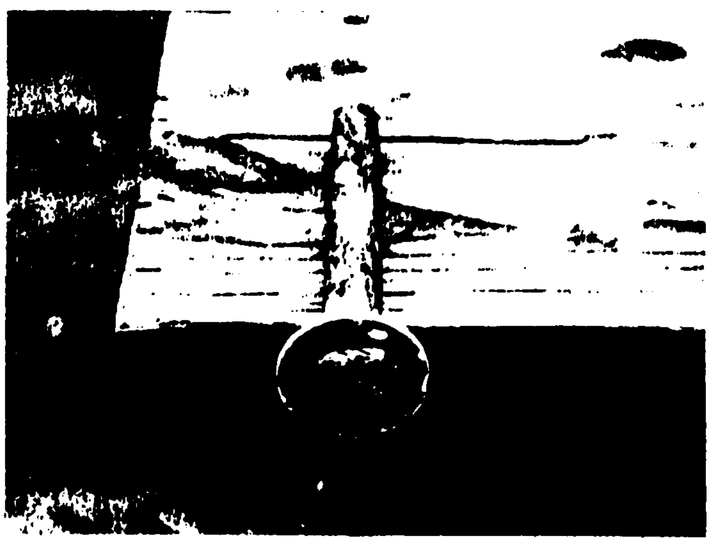

Figure 15. Container Guide Rail Locking Pin

In addition, it was found that a portion of the Container Guide Rail did not provide sufficient clearance to permit full insertion (from the outside to the inside) of one of the pins. The flange on the head of the pin was too wide (Figure 16). As an expedient measure, the pin was inserted from the inside to the outside. Although use of this expedient measure provided valid trials, the situation should be reviewed and redesign considered.

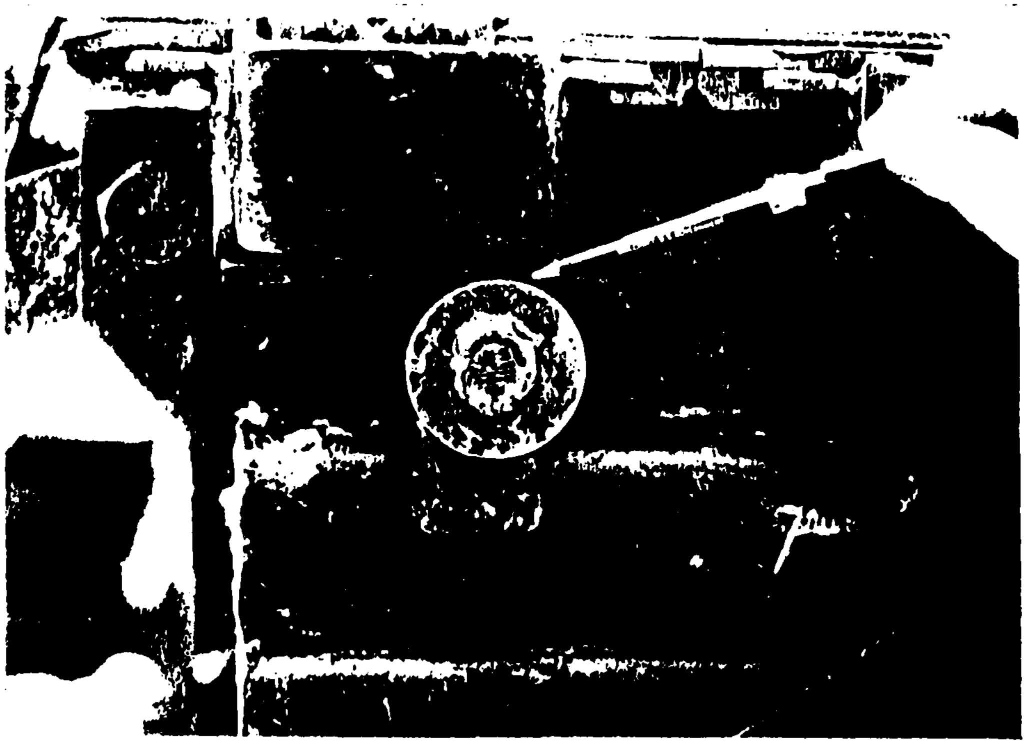

Figure 16. Locking Pin inserted in Container Guide Rails

Table 5 provides a summary comparison of the Phase I HIK versus the Phase II HIK design characteristics and performance.

Table 5. Phase I Design versus Phase II Design

Characteristic	Phase I Design	Phase II Design
Weight of Container Guide Rail and Load Transport Subassemblies	1700 lb	1312 lb
Weight of Cruciform	1100 lb	800 lb
Length of Container Guide Rail Subassembly	58 in	46 in
Time to Convert Container Guide Rail and Load Transport Rail from Storage to Ready-to-Load	≈10 mins*	1.90 mins
Time to Convert Container Guide Rail and Load Transport Rail from Ready-to-Load to Storage	≈10 mins*	2.36 mins
Time to Attach/upload a Fully Loaded ISO Container	4.93 mins	3.14 mins**
Time to Download/detach a Fully Loaded ISO Container	3.21 mins	1.58 mins**

*Estimate - never tested

**The Government is in the process of procuring a Model "B", Phase II design cruciform subassembly which contains an automatic air lock for locking the lower end container corner castings onto the cruciform from within the vehicle cab. This operation is performed manually with the Model "A" cruciform that was tested. At the time of testing, the Model B had not been received so no test data is included in this report. It is estimated that the times marked with an asterisk would be less with the air lock mechanism on Model "B".

CONCLUSIONS

General:

1. The use of the HIK as a subsystem of the PLS significantly enhances the capability of the PLS by giving it a capability to upload, transport and download the 3.5 million commercial 8' x 8 1/2' x 20' ANSI ISO containers used throughout the world for the transport of cargo, without the use of the PLS flatrack or any special cranes or mechanical lifting devices. Based on the estimated 50,000 commercial containers which can be expected to be available for military use during a military emergency from the

worldwide inventory,[1] plus the capability to pick up a variety of special military shelters such as hospital and communications shelters, the capability of the PLS fleet based on a planned procurement of only 34,160 PLS flatracks can be more than doubled by the use of the HIK. The HIK has the capability of picking up any container from the entire worldwide inventory (3.5 million) of commercial 8' and 8 1/2' x 20 ' containers.

2. Because of the significant increase in performance capabilities of the PLS by the HIK, acceptance of this kit by the users will have a major impact on the procurement plans of the PLS.

3. Because of the flexibility of the PLS as a military cargo vehicle to serve many users, further enhancements to the Palletized Loading System to expand the capabilities of this versatile system should be given priority consideration.

__Specific__

1. The Phase II HIK is superior in design and performance in comparison with the Phase I HIK:

a. It is approximately 700 lb lighter than the Phase I design.

b. An ANSI ISO container fully loaded with ammunition can be picked up with the PLS LHS and loaded and secured on the PLS in an average time of 3.14 minutes as compared with 4.93 minutes with the Phase I HIK. This represents a savings of 37 percent.

d. Conversion of the Phase II HIK from an operational mode to an on-vehicle stowage mode for transport of standard flatracks requires 2.36 minutes as compared with an estimated time of 10 minutes for the Phase I HIK. Also, the Phase II design is converted from an operational mode to an on-vehicle mode via a sliding motion rather than a lifting and folding motion which eliminates the safety hazards associated with the Phase I design. Conversion of the Phase I design from an operational mode to an on vehicle stowage mode required the complete removal of the Load Transport Rail

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[1] US DOT Research and Special Projects Administration, Transportation Systems Center Report WP-46-Up-134, Edward Gough, Bruce J. Weiers, Donna Woodman, "Availability of Ammunition-Serviceable Containers". July 1987, Dendall Square, Cambridge, MA 02141

subassembly and stowage elsewhere on the vehicle. The Phase II design requires only the removal of a single pin, tilting the top part of the component 90 degrees towards the center of the vehicle and reinsertion of the pin (eliminating the necessity for removal and stowage elsewhere).

RECOMMENDATIONS

It is recommended that:

a. The results of Phase II testing be briefed to the appropriate TRADOC Organizations together with copies of this report for development of supporting Organizational and Operational (O&O) Plans and the establishment of quantitative requirements.

b. The Level 1 drawings of the HIK together with a copy of this report be turned over to an AMC Research and Development Command for development and fielding as part of the Palletized Loading System.